THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

FIRST SEMESTER EXAMINATION

CH214 – APPLIED PHYSICAL CHEMISTRY

MONDAY 22nd JUNE 2020 - 12:50 PM

TIME ALLOWED: 2 HOURS

INFORMATION FOR CANDIDATES:

1. You will have 10 minutes to read the question paper. You **MUST NOT** begin writing in the answer book during this time.
2. **ANSWER ALL QUESTIONS.**
3. All answers **MUST** be written on the answer book provided.
4. Calculators are permitted in the examination room, IF NECESSARY. Lecture notes, notebooks, plain papers, and textbooks are **NOT** allowed.
5. Mobile phones are not allowed. **SWITCH OFF THE MOBILE PHONES.**
6. Show all working and calculations in the answer book.
7. **DRAW any FIGURES** clearly and visibly.
8. **DO NOT** over write
9. Write your name and number clearly on the front page of the answer book. **DO IT NOW.**

MARKING SCHEME: [TOTAL 50 MARKS]

CH214 – 2020

1. Consider the thermodynamic data at 298K presented in the Table below:

	ΔH_f^o kJ/mol	ΔG_f^o kJ/mol	S_f^o J/mol/K
$Sr(IO_3)_2$ (s)	-1019.2	-855.1	234
Sr^{2+} (aq)	-545.8	-599.5	-32.6
IO_3^- (aq)	-221.3	-128.0	118.4

(a) Calculate the ΔG^o for the reaction $Sr(IO_3)_2$ (s) $\leftrightarrow$ Sr^{2+} (aq) + $2IO_3^-$ (aq). Show all calculations clearly. No short cut.

[4 marks]

(b) From your result in 1(a) above, what is the K_{sp} for $Sr(IO_3)_2$?

[2 marks]

(c) From your result in 1(b) above, what is the molarity of a saturated aqueous solution of $Sr(IO_3)_2$ at 298K?

[4 marks]

(TOTAL: 10 MARKS)

2. The equation for the thermal decomposition of NO_2 at 330°C is given below:

$$2NO_2\ (g) \longrightarrow 2NO\ (g) + O_2\ (g)$$

The change in concentration of NO_2 was studied over a period time, and the kinetics data is presented in the table below:

Time (s)	$[NO_2]$ (M)	$\ln[NO_2]$	$1/[NO_2]$ (M^{-1})
0	1.00×10^{-2}	-4.605	100
60	6.83×10^{-3}	-4.986	146
120	5.18×10^{-3}	-5.263	193
180	4.18×10^{-3}	-5.477	239
240	3.50×10^{-3}	-5.655	286
300	3.01×10^{-3}	-5.806	332
360	2.64×10^{-3}	-5.937	379

(a) Using the graph paper provided, plot a graph of $1/[NO_2]$ in M^{-1} on the vertical axis, against time (s) on the horizontal axis. Try and cover the entire area on the graph sheet.

[6 marks]

(b) Based on the nature of the graph, what is the order of the reaction?

[2 marks]

(c) From 2(a) above, calculate the rate constant, k for the reaction.

[4 marks]

(TOTAL: 12 MARKS)

3. The equilibrium condition for SO_2 (g), O_2 (g), and SO_3 (g) is important in the production of sulfuric acid in industry. The equation for the reaction is given below:

$$2SO_{3\,(g)} \leftrightarrow 2SO_{2\,(g)} + O_{2\,(g)}$$

When a 0.0200 mole sample of SO_3 is introduced into an evacuated 1.52 L

reaction vessel at 900K, 0.0142 mole SO_3 was present at equilibrium.

(a) Set up a complete ICE Table for the reaction showing all initial concentrations, changes that occurred for each substance, and equilibrium concentrations for each during the reaction.

[5 marks]

(b) From 3 (a) above, calculate the equilibrium constant K_c for the dissociation of SO_3 (g) at 900K.

[3 marks]

(TOTAL: 8 MARKS)

4. A possible reaction for converting methanol to ethanol is as follows:

$$CO\ (g) + 2H_2\ (g) + CH_3OH\ (g) \longrightarrow C_2H_5OH\ (g) + H_2O\ (g)$$

You are provided with the following thermodynamic data at 298K:

	ΔH_f^o kJ/mol	ΔG_f^o kJ/mol	S_f^o J/mol/K
CO (g)	-110.5	-137.2	197.7
H_2 (g)	0	0	130.7
CH_3OH (g)	-200.7	-162.0	239.8
C_2H_5OH (g)	-235.1	-168.5	282.7
H_2O (g)	-241.8	-228.6	188.8

(a) Calculate ΔH^o for the reaction at 298K.

[4 marks]

(b) Calculate ΔS^o for the reaction at 298K.

[4 Mark]

(c) Calculate ΔG^o for the reaction at 298K.

[4 marks]

(d) Calculate the K_p for the reaction at 750K

[8 marks]

(e) Is the reaction thermodynamically favoured at high, or low temperature? How do you know?

(TOTAL: 20 MARKS)

----------THE END----------

EQUATIONS SHEET

$\Delta G^o = \Delta H^o - T\Delta S^o$

$\Delta G^o = -RT \ln K_p$

$$\ln K_2 - \ln K_1 = \frac{\Delta H^o}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$$\frac{1}{[A]_t} = akt + \frac{1}{[A]_o}$$

$$[A]_t = -akt + [A]_0$$

$$\ln[A]_t = -akt + \ln[A]_o$$

$R = 8.314\ J\ mol^{-1}K^{-1}$